Table 11. IR method: concentration ranges bracketing applicable exposure limits for which the NIOSH accuracy criterion is met* ($\mu g/m^3$)

Cyclone and sampling rate	Filter loading			Applicable exposure limit
	6.72 μg	**99.7 μg**	**161 μg**	
Nylon cyclone, 1.7 L/min	83	123	198	100
GK2.69 cyclone, 4.2 L/min	34	50	80	50

*Eight-hour sampled masses are combined with results of NIOSH, BOM [1983].

Table 12. Predicted incidence or prevalence of silicosis following exposure to selected concentrations of respirable quartz dust—based on modeling of cumulative exposure over a 45-year working lifetime

Study and cohort	Selected mean concentration of respirable quartz dust (mg/m^3)	Mean time since first quartz exposure (yr)	Maximum time since first quartz exposure (yr)	Predicted incidence or prevalence of silicosis, ILO category ≥ 1/1 (cases/100 workers)
Hnizdo and Sluis-Cremer [1993], 2,235 South African gold miners	0.05	36[*]	50[*]	13[†]
	0.10	—	—	70[‡]
Hughes et al. [1998], 2,342 U.S. workers in a diatomaceous earth mining and processing facility	0.05	11.5	46	1.5[§]–4[‡,**]
	0.10	—	—	4[§]–17[‡,**]
Kreiss and Zhen [1996], 100 U.S. hardrock miners and 34 community controls	0.05	41.6[*]	66[*]	30[‡,††]
	0.10	33.5[‡‡]	68[‡‡]	90[‡,††]
Muir et al. [1989a,b] and Muir [1991], 2,109 Canadian gold and uranium miners	0.05	18	38[*]	0.09–0.62[§§]
Ng and Chan [1994], 338 Hong Kong granite workers	0.045[‡,***]	—[†††]	—[†††]	6
Rosenman et al. [1996], 1,072 U.S. gray iron foundry workers	0.05	28	>30	2[‡‡‡]
	0.10	—	—	3[‡‡‡]
Steenland and Brown [1995a], 3,330 U.S. gold miners	0.05	37	73[§§§]	10[****]
	0.09	—	—	47[****]

[*]Silicotic miners.
[†]Estimate reported in Rice and Stayner [1995].
[‡]Approximate.
[§]Primarily cristobalite dust. Cumulative risk of small opacities ≥ILO category 1/0 and/or large opacities. For 1,452 workers with an average crystalline silica exposure ≤0.50 mg/m^3; 1,138 (78%) of these workers were hired in 1950 or later.
[**]Primarily cristobalite dust. Cumulative risk of small opacities ≥ILO category 1/0 and/or large opacities. For 357 workers with an average crystalline silica exposure >0.50 mg/m^3; 319 (89%) of these workers were hired before 1950.
[††]Based on cumulative silica exposure model with 10 yr of post-employment followup.
[‡‡]Nonsilicotic miners.
[§§]No post-employment followup and no retired miners included. The range includes five estimates (one for each reader). Estimate reported in Rice and Stayner [1995].
[***]Based on a 50-year-old worker with cumulative silica exposure of 2 $mg/m^3 \cdot yr$.
[†††]Not reported. Mean duration of employment was 17 yr for all workers and 27.5 yr for workers in the highest category of cumulative silica exposure.
[‡‡‡]ILO category ≥1/0. Based on a 40-yr working lifetime and controlling for pack-years of cigarette smoking, race, and silica exposure other than in the foundry under study.
[§§§]Steenland [1998].
[****]Includes 141 cases documented on death certificate only. Estimated risk not adjusted for age or calendar time [Steenland 1997].

Table 13. Summary of epidemiologic studies of silicosis with cumulative dust exposure data and silicosis risk estimates

Reference, country, and study design	Cohort	Definition of silicosis, mean duration of employment, and mean yr since first quartz exposure	Silica (quartz) content of respirable dust	Measure of association	Comments
Hnizdo and Sluis-Cremer [1993], South Africa, cohort study	2,235 white underground gold miners who were aged 45 to 54 at time of medical examination in 1968–1971, started working after 1938, worked ≥10 yr, and were followed until 1991.	ILO* category ≥1/1and rounded opacities (313 cases); 23.5 yr for total cohort and 26.9 yr for cases; 36 yr for cases.	30% after heat and acid treatment [Beadle and Bradley 1970].	Cumulative risk	Authors speculated that these silicosis risk estimates were higher than estimates for Canadian miners reported by Muir et al. [1989a,b] and Muir [1991] because (1) dust exposure may have been under-estimated, (2) South African gold mine dust may be more fibrogenic than Canadian mine dust, (3) average proportion of quartz may be >30%, (4) there may have been differences in age at end of radiological follow-up, and (5) exposures for Canadian miners (Hnizdo's [1995] response to Hughes and Weill [1995]) may have been overestimated.

See footnotes at end of table.

(Continued)

Table 13 (Continued). Summary of epidemiologic studies of silicosis with cumulative dust exposure data and silicosis risk estimates

Reference, country, and study design	Cohort	Definition of silicosis, mean duration of employment, and mean yr since first quartz exposure	Silica (quartz) content of respirable dust	Measure of association	Comments
Hughes et al. [1998], United States, retrospective cohort study	2,342 white male workers employed at least 1 yr between 1942 and 1987 in one diatomaceous mining and processing facility. Exposure-response analyses included the 1,809 men with a radiograph taken more than 1 month after hire.	Small opacities ≥ILO profusion category 1/0 and/or large opacities (81 cases); 5.54 yr[†]; 11.5 yr.	Natural diatomite, 3%; calcined diatomite, 20%; flux-calcined diatomite, 60% (see comments).	Cumulative risk	82 workers had radiographs taken after retirement—development of opacities was not recorded for other workers after they left employment. Quantitative air-monitoring data were available after 1948; respirable dust concentrations before 1948 were estimated [Seixas et al. 1997]. Cumulative risk estimates for radiographic opacities were lower for workers who were hired after 1950 and who had lower average exposures to crystalline silica dust (mainly cristobalite). Estimated percentages of respirable crystalline silica reported by Checkoway et al. [1997] in mortality study of same cohort: 10% for calcined diatomaceous earth, and 20% for flux-calcined diatomaceous earth.

See footnotes at end of table.

(Continued)

Table 13 (Continued). Summary of epidemiologic studies of silicosis with cumulative dust exposure data and silicosis risk estimates

Reference, country, and study design	Cohort	Definition of silicosis, mean duration of employment, and mean yr since first quartz exposure	Silica (quartz) content of respirable dust	Measure of association	Comments
Kreiss and Zhen [1996], United States, community-based random sample survey	134 male residents of a hardrock[‡] mining town who were aged ≥40: 100 silica-exposed hardrock miners (included 32 silicosis cases) and 34 community controls without occupational dust exposure.	ILO category ≥1/0; 27.6 yr for silicotics and 22.9 yr for nonsilicotic miners; 41.6 yr for silicotics and 33.5 yr for nonsilicotics.	12.3%	Prevalence	Possible overestimation of silicosis risk because of underestimation of pre-1974 dust and silica exposures. Exposures were also estimated for mines where there were no exposure data (17.1% of the person-yr of followup). Risk estimates were presented for models of cumulative silica dust exposure or cumulative dust exposure—the models of cumulative silica dust exposure gave higher estimates. Silicosis (i.e., ≥ category 1/1) risk estimates from models of cumulative dust exposure were similar to estimates for South African gold miners [Hnizdo and Sluis-Cremer 1993] and U.S. gold miners [Steenland and Brown 1995a].

See footnotes at end of table.

(Continued)

Table 13 (Continued). Summary of epidemiologic studies of silicosis with cumulative dust exposure data and silicosis risk estimates

Reference, country, and study design	Cohort	Definition of silicosis, mean duration of employment, and mean yr since first quartz exposure	Silica (quartz) content of respirable dust	Measure of association	Comments
Muir et al. [1989a,b], Verma et al. [1989], Muir [1991]; Canada; retrospective cohort study	2,109 current Ontario gold and uranium miners who started and worked ≥5 yr between 1940 and 1959 and were followed to 1982 or to the end of their dust exposure, whichever came first.	ILO category ≥1/1 and small, rounded opacities (32 cases); approximately 20 yr; approximately 25 yr (based on interpretation of data in table and graph of Muir et al. [1989b]).	6.0% for gold mine dust; 8.4% for uranium mine dust.	Cumulative risk	Retired and former workers not included, which may have underestimated silicosis risk. Disagreement about silicosis classification among the five readers of the chest X-rays may have "complicated the analysis" [Muir et al. 1989b].

See footnotes at end of table.

(Continued)

Table 13 (Continued). Summary of epidemiologic studies of silicosis with cumulative dust exposure data and silicosis risk estimates

Reference, country, and study design	Cohort	Definition of silicosis, mean duration of employment, and mean yr since first quartz exposure	Silica (quartz) content of respirable dust	Measure of association	Comments
Ng and Chan [1994], Hong Kong, cross-sectional study	338 current and previous granite workers employed ≥1 yr between 1967 and 1985.	ILO category ≥1/1 (rounded or irregular opacities); 17.4 yr; not reported.	27%	Prevalence	Cumulative risks not calculated. Exposure data for 1976–1981 in one quarry and for 1971–1975 and 1976–1981 in another quarry were not available and were assumed to be the same concentrations measured in 1982 for the period 1976–1981 and in 1971 for the period 1971–1985 [Ng et al. 1987]. Possible under-estimate of silicosis risk because decedents were not included.

See footnotes at end of table.

(Continued)

Table 13 (Continued). Summary of epidemiologic studies of silicosis with cumulative dust exposure data and silicosis risk estimates

Reference, country, and study design	Cohort	Definition of silicosis, mean duration of employment, and mean yr since first quartz exposure	Silica (quartz) content of respirable dust	Measure of association	Comments
Rosenman et al. [1996], United States, cross-sectional study	549 current, 497 retired, and 26 current salaried workers that were former production workers in a gray iron foundry that produced automotive engine blocks (total workers=1,072).	ILO category ≥1/0 and rounded opacities (28 cases); 19.2 yr; 28.3 yr.	Not reported.	Prevalence	Prevalence of silicosis cases increased with (1) years of employment, (2) cigarette smoking, (3) mean silica exposure, and (4) cumulative silica exposure. Exposure estimates were derived from conversions of "early silica exposure data" collected by impingers. Underascertainment of silicosis cases is likely because there was no systematic radiologic followup of retired workers. Results showed that African-American workers had two times the risk of radiographic silicosis compared with white workers but a similar duration of employment; however, African-American workers had greater mean exposure to silica dust. When exposure to silica was controlled for in the analysis, the prevalence of radiographic silicosis was similar for African-American workers and white workers.

See footnotes at end of table.

(Continued)

Table 13 (Continued). Summary of epidemiologic studies of silicosis with cumulative dust exposure data and silicosis risk estimates

Reference, country, and study design	Cohort	Definition of silicosis, mean duration of employment, and mean yr since first quartz exposure	Silica (quartz) content of respirable dust	Measure of association	Comments
Steenland and Brown [1995a], United States, cohort study	3,330 white male underground gold miners employed ≥1 yr between 1940 and 1965 and followed through 1990.	Mortality[§] and ILO category ≥1/1 (1976 radiographic survey) or "small opacities" or "large opacities" (1960 radiographic survey) (170 cases); 9 yr; 37 yr.	13% [Zumwalde et al. 1981]	Cumulative risk	Silicosis risk estimates could have been affected by (1) combining silicosis deaths with silicosis cases detected by cross-sectional radiographic surveys, (2) difference in quartz content of dust in early years, (3) lack of dust measure-ments before 1937.

[*]International Labour Organization.
[†]Median [Checkoway et al. 1997].
[‡]Molybdenum, lead, zinc, and gold mining.
[§]Underlying or contributing cause of death was silicosis, silico-tuberculosis, respiratory tuberculosis, or pneumoconiosis.

Table 14. Selected age-adjusted PMRs[*,†] for pulmonary TB by usual occupation, sex, and race in 28 States, 1979–1990

Occupation of decedent and 1980 census code	Male decedents						Female decedents					
	White			Black			White			Black		
	Number	PMR	95% CI	Number	PMR	95% CI	Number	PMR	95% CI	Number	PMR	95% CI
Construction occupations (553–599, 865, and 869)	169	134[†]	114–156	105	128[†]	104–155	0	—	—	0	—	—
Brick and stone mason (553 and 563–564)	12	213[†]	110–371	11	159	80–285	0	—	—	0	—	—
Carpenter (554, 567, and 569)	50	147[†]	109–194	9	97	44–184	0	—	—	0	—	—
Roofer (595)	6	290[†]	106–630	1	53	1–293	0	—	—	0	—	—
Construction laborer (869)	34	175[†]	121–244	61	156[†]	120–201	0	—	—	0	—	—
Mining machine operator (616)	54	276[†]	207–360	4	128	35–328	0	—	—	0	—	—
Grinding, abrading, buffing, or polishing machine operator (709)	7	265[†]	107–547	1	94	2–523	0	—	—	0	—	—
Mixing or blending machine operator (756)	1	58	2–326	5	376[†]	122–878	0	—	—	0	—	—
Furnace, kiln, or oven operator, except food (766)	1	27	1–153	5	206[†]	67–481	0	—	—	1	15,000	372–82,842
Laborer, except construction (889)	85	159[†]	127–196	92	111	89–136	12	162	84–283	8	147	64–291

Source: Adapted from CDC [1995]. This data file includes death records from 28 States (Alaska, California, Colorado, Georgia, Idaho, Indiana, Kansas, Kentucky, Maine, Missouri, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Tennessee, Utah, Vermont, Washington, West Virginia, and Wisconsin).

[*]Abbreviations: PMRs = proportionate mortality ratios; TB = tuberculosis; CI = confidence interval.

[†]Selection criteria: (1) at least four TB deaths in race- and sex-specific group and (2) either a PMR >200 or a PMR with a 95% CI excluding 100.

See footnotes at end of table.

(Continued)

Table 15. IARC[*]-reviewed epidemiologic studies having the least confounded investigations of an association between occupational exposure to crystalline silica and lung cancer

Reference and country	Study design, cohort, and followup	Subgroup	Number of lung cancer deaths or cases	Risk measure[†]	CI[‡]	Smoking information available and analyzed	Comments
Amandus et al. [1991], United States	Mortality study of 714 male, North Carolina dusty trades workers diagnosed with silicosis between 1940 and 1983 and compared with the 1940–1983 lung cancer mortality rates for U.S. males.	Whites	33	2.6	1.8–3.6	Yes	The age- and smoking-adjusted rate ratio for white silicotics with lung cancer was 3.9 (95% CI= 2.4–6.4) compared with a referent group of metal miners.
		Nonwhites	1	0.7	Not reported		
		White silicotics:					
		Diagnosed while employed	28	2.5	1.7–3.7		"Exposure to respirable silica dust" was defined as working in a dusty trade and having radio-graphic silicosis.
		Employed in jobs with silica exposure only[§]	26	2.3	1.5–3.4		
		Past or current smokers	18	3.4	2.0–5.3		No quantitative exposure data were available.
		Silicotics, never smoked	5	1.7	0.5–3.9		
Amandus et al. [1992], United States	Mortality study of subgroup of 306 white males from Amandus et al. [1991] cohort of silicotics diagnosed and traced from 1940 through 1983. 143 of the subgroup were reclassified as silicotics, and 96 were reclassified as having a normal radiograph. 10 deaths from lung cancer occurred in the reclassified group.	Silicotics	8	2.5	1.1–4.9	Yes	"Exposure to respirable silica dust" was defined as working in a dusty trade and having radiographic silicosis.
		Nonsilicotics[**]	2	1.0	0.1–3.5		
		Smokers:					
		Silicotics	5	3.4	1.1–7.9		
		Nonsilicotics[**]	1	1.3	0.03–7.1		No quantitative exposure data were available.

Table 15 (Continued). IARC[*]-reviewed epidemiologic studies having the least confounded investigations of an association between occupational exposure to crystalline silica and lung cancer

See footnotes at end of table.

(Continued)

Reference and country	Study design, cohort, and followup	Subgroup	Number of lung cancer deaths or cases	Risk measure[†]	CI[‡]	Smoking information available and analyzed	Comments
Burgess et al. [1997], Cherry et al. [1997], McDonald et al. [1997], United Kingdom	Nested case-control study of lung cancer deaths within Cherry et al. [1995], including duration and intensity of exposure, smoking, and radiological changes. Cases were employed as pottery workers for ≥10 yr. Each death was matched with 3 or 4 controls on date of birth and date of first exposure.	Cumulative exposure to respirable crystalline silica dust ≥4,000 μg/m^3·yr	52	0.60[††]	0.26–1.41[‡‡]	Yes	ORs were adjusted for smoking and radio-graphic changes. This was the only epidemiologic study of peak exposure effects and lung cancer. Results support significant lung cancer risk for high-intensity silica exposures. Silica dust exposures ≥400 μg/m^3 occurred in firing and post-firing operations. Exposures to cristobalite were possible.
		Duration of employment ≥20 yr	—	0.48[††]	0.21–1.09[‡‡]		
		Mean intensity of silica dust exposure ≥200 μg/m^3	—	1.68[††]	0.93–3.03[‡‡]		
		Maximum silica dust exposure ≥400 μg/m^3	—	2.07[††]	1.04–4.14[‡‡]		

See footnotes at end of table.

(Continued)

Table 15 (Continued). IARC[*]-reviewed epidemiologic studies having the least confounded investigations of an association between occupational exposure to crystalline silica and lung cancer

Reference and country	Study design, cohort, and followup	Subgroup	Number of lung cancer deaths or cases	Risk measure[†]	CI[‡]	Smoking information available and analyzed	Comments
Checkoway et al. [1993; 1996], United States	Mortality study of 2,570 male workers at diatomaceous earth plants employed ≥1 yr and worked ≥1 day between 1942 and 1987. Cohort mortality traced for that period.	—	59	1.43	1.09–1.84	Limited to comparisons of smoking prevalence.	Estimated relative risks for lung cancer (not shown) were adjusted for age, calendar year, dura-tion of followup, and ethnicity. The risks in-creased significantly ($P \leq 0.05$ for trend) with duration of employment and cumulative exposure to crystalline silica [Checkoway et al. 1993]. Checkoway et al. [1996] also adjusted for asbestos exposure.
	Checkoway et al. [1996] reanalyzed 2,266 work-ers (a subset of the orig-inal cohort). Mortality traced from 1942 through 1987.	—	52	1.41	1.05–1.85		
Cherry et al. [1995], United Kingdom	Mortality study of 5,115 pottery workers, ex-cluding exposure to asbestos, foundry, and other dusts; with mortality followup to June 30, 1992.	—	68	1.28	1.04–1.57[‡‡]	No	Lung cancer rates in pot-tery workers were com-pared with local mor-tality rates.

See footnotes at end of table.

(Continued)

Table 15 (Continued). IARC[*]-reviewed epidemiologic studies having the least confounded investigations of an association between occupational exposure to crystalline silica and lung cancer

Reference and country	Study design, cohort, and followup	Subgroup	Number of lung cancer deaths or cases	Risk measure[†]	CI[‡]	Smoking information available and analyzed	Comments
Costello and Graham [1988], United States	Mortality study of 5,414 white male workers in Vermont granite sheds and quarries employed between 1950 and 1982 with at least one radiologic examination in the worker surveillance program.	Quarry workers	20	0.82	Not reported	No	Dust exposure data were not included, limiting conclusions about exposure-response. Cohort overlaps with cohort of Davis et al. [1983].
		Shed workers:	98	1.27	Not reported[§§]		
		Started before 1940, latency period ≥40 yr, tenure ≥30 yr	47	1.81	1.33–2.41[***]		
		Started after 1940, latency period ≥25 yr, tenure ≥10 yr	17	1.73	1.01–2.77		CIs reported by IARC [1997].
Costello et al. [1995], United States	Mortality study of 3,246 male workers employed ≥1 yr between 1940 and 1980 at 20 U.S. crushed stone (i.e., granite, limestone, traprock, or sandstone) operations.	Whites	40	1.2	0.9–1.6	No	—
		Nonwhites	11	1.9	0.9–3.3		
		Workers in granite facilities with ≥20-yr latency period and ≥10-yr tenure	7	3.5	1.4–7.3		
		Workers in limestone facilities	23	1.5	1.0–2.3		
		Workers in traprock facilities	3	0.6	0.1–1.8		

See footnotes at end of table.

(Continued)

Table 15 (Continued). IARC[*]-reviewed epidemiologic studies having the least confounded investigations of an association between occupational exposure to crystalline silica and lung cancer

Reference and country	Study design, cohort, and followup	Subgroup	Number of lung cancer deaths or cases	Risk measure[†]	CI[‡]	Smoking information available and analyzed	Comments
Dong et al. [1995], China	Mortality study of lung cancer in 6,266 male silicotic and nonsilicotic refractory brick workers employed before 1962 and followed for mortality from 1963 to 1985. 11,470 nonsilicotic male steel workers used as controls.	Silicotics	35	2.1[†††]	Not reported[***]	Yes	Twofold excess lung cancer mortality occurred in both smokers and nonsmokers. Exposure-response trends were found for years since first employment and lung cancer mortality, and for severity of silicosis and lung cancer mortality.
		Silicotics in Chinese radiological category:					
		I	21	2.0	Not reported[***] Not reported[§§]		
		II	10	2.3	Not reported[§§]		
		III	4	2.6	Not reported[***]		
		Nonsilicotics	30	1.1			
Guénel et al. [1989], Denmark	Cohort study of 2,175 Danish stone workers who met the following criteria: • were alive on Jan. 1, 1943, or were born later, and • were aged <65 when first identified in one of 6 data sources. The cohort included 2,071 cancer cases identified in the Danish cancer registry between 1943 and 1984.	Lung cancer cases	44	2.00[‡‡‡]	1.49–2.69	Yes	Adjusted for regional differences in smoking. Lung cancer mortality highest among Copenhagen sandstone cutters hired before 1940 prior to ventilation improve-ments.

See footnotes at end of table.

(Continued)

Table 15 (Continued). IARC[*]-reviewed epidemiologic studies having the least confounded investigations of an association between occupational exposure to crystalline silica and lung cancer

Reference and country	Study design, cohort, and followup	Subgroup	Number of lung cancer deaths or cases	Risk measure[*]	CI[†]	Smoking information available and analyzed	Comments
McDonald et al. [1995], United Kingdom	Preliminary report of proportionate mortality study of 7,020 pottery workers born between 1916 and 1945 with mortality followup to June 30, 1992. Prelim-inary nested case-control study of 75 lung cancer cases and 75 controls.	Lung cancer deaths in pottery workers not exposed to asbestos	112	1.22[§§§]	1.04–1.43[‡‡]	No	Preliminary results (final results in Cherry et al. [1995]).
		Smokers and nonsmokers with ≥10 yr of silica exposure	75	1.4[††]	0.7–2.7[‡‡]		Lung cancer rates in pottery workers were compared with local mor-tality rates.
		Smokers with ≥10 yr of silica exposure	47	2.8[††]	1.1–7.5[‡‡]		
McLaughlin et al. [1992], China	Nested case-control study of 62 pottery fac-tory workers employed between 1972 and 1974 who died from lung cancer before 1990; 238 controls matched by decade of birth and factory.	Cumulative respirable silica dust exposure (μg/m3·yr):				Yes	ORs were adjusted for age and smoking. Test for exposure-response trend was not statistically significant (P>0.05) for cumulative exposure to dust or respirable silica. High OR (7.4; CI and number of deaths not reported) for lung cancer in workers who smoked >20 cigarettes per day. CIs reported in IARC monograph [1997].
		None					
		Low (0.1–8.69)	11	1.0	—		
		Medium (8.70–26.2)	17	1.8	1.04–2.87		
		High (≥26.3)	27	1.5	0.99–2.18		
			7	2.1	0.80–4.12		

See footnotes at end of table.

(Continued)

Table 15 (Continued). IARC[*]-reviewed epidemiologic studies having the least confounded investigations of an association between occupational exposure to crystalline silica and lung cancer

Reference and country	Study design, cohort, and followup	Subgroup	Number of lung cancer deaths or cases	Risk measure[†]	CI[‡]	Smoking information available and analyzed	Comments
Merlo et al. [1991], Italy	1,022 male refractory brick workers employed at least 6 months between 1954 and 1977. Retrospective cohort study of mortality through 1986.	All brick workers	28	1.51	1.00–2.18	Yes	Smoking habits of cohort comparable with the national population (includes the men in Puntoni et al. [1988]).
		Brick workers:					
		≤19 yr since 1st exposure and employed ≤19 yr	7	1.05	0.42–2.16		
		>19 yr since 1st exposure and employed ≤19 yr	8	1.75	0.75–3.46		
		>19 yr since 1st exposure and employed >19 yr	13	2.01	1.07–3.44		

See footnotes at end of table.

(Continued)

Table 15 (Continued). IARC*-reviewed epidemiologic studies having the least confounded investigations of an association between occupational exposure to crystalline silica and lung cancer

Reference and country	Study design, cohort, and followup	Subgroup	Number of lung cancer deaths or cases	Risk measure†	CI‡	Smoking information available and analyzed	Comments
Partanen et al. [1994], Finland	Cohort study of 811 male silicotics, compen-sated and not compen-sated, who were diag-nosed between 1936 and 1977 in Finland. Cancer incidence for 1953–1991 was obtained from the Finnish Cancer Registry.	Length of followup from date of silicosis diagnosis:				Yes	Update of Kurppa et al. [1986].
		<2 yr	1	0.4§§§	0.01–2.3		
		2–9 yr	32	2.7	1.9–3.9		No evidence of con-founding by tobacco smoking.
		≥10 yr	168	3.3	2.5–4.1		
		Histology of lung cancers:					
		Adenocarcinoma	5	2.0	0.6–4.6		
		Squamous-cell	34	3.2	2.3–4.5		
		Small-cell	9	2.1	0.9–3.9		
		Other/unknown	53	3.0	2.2–3.9		
		Industry:					
		Mining/quarrying (excluding granite)	38	3.7	2.6–5.0		
		Granite	13	2.9	1.6–5.0		
		Glass/ceramic	10	3.3	1.6–6.1		
		Grinding/sharpening	3	3.0	.6–8.7		
		Casting/founding	22	1.8	1.1–2.6		
		Construction	2	10	1.3–37		
		Excavation/foundation	9	5.8	2.7–11.1		

See footnotes at end of table.

(Continued)

Table 15 (Continued). IARC[*]-reviewed epidemiologic studies having the least confounded investigations of an association between occupational exposure to crystalline silica and lung cancer

Reference and country	Study design, cohort, and followup	Subgroup	Number of lung cancer deaths or cases	Risk measure[†]	CI[‡]	Smoking information available and analyzed	Comments
Steenland and Brown [1995b], United States	Cohort study of 3,328 white male gold miners employed underground ≥1 yr between 1940 and 1965 and followed for mortality from 1977 to 1990. Mortality rates of U.S. males used for comparison.	—	115	1.13	0.94–1.36	Yes	High historical expo-sures. No exposure-response trend by cumu-lative dust exposure. Low radon and arsenic exposures.

Source: IARC [1997].

[*]Abbreviations: CI=confidence interval; IARC=International Agency for Research on Cancer; PMR=proportional mortality ratio; OR=odds ratio; SIR=standardized incidence ratio; SMR=standardized mortality ratio; SRR=standardized rate ratio

[†]SMR unless otherwise noted.

[‡]95% CI unless otherwise noted.

[§]Workers who had no known exposure to other occupational carcinogens such as asbestos manufacturing, insulation work, olivine mining, talc, and foundry work.

[**]Nonsilicotics are subjects with normal radiographs.

[††]OR.

[‡‡]90% CI.

[§§]$P < 0.05$.

[***]$P < 0.01$.

[†††]Values in this study are SRRs.

[‡‡‡]Values in this study are SIRs.

[§§§]PMR.